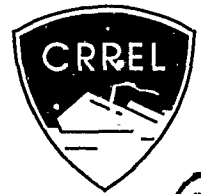
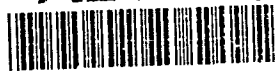


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Management of Vegetation on Ammunition Magazines at AMC Facilities

A.J. Palazzo, C.H. Racine, W. Woodson, D.E. Pidgeon
and D.W. Cate

June 1991

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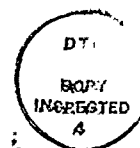


**U.S. Army Corps
of Engineers**
Cold Regions Research &
Engineering Laboratory

Management of Vegetation on Ammunition Magazines at AMC Facilities

A.J. Palazzo, C.H. Racine, W. Woodson, D.E. Pidgeon
and D.W. Cate

June 1991



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PREFACE

This report was prepared by Antonio J. Palazzo, Research Agronomist, Geochemical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL); Dr. Charles H. Racine, Research Biologist, Geological Sciences Branch, Research Division, CRREL; William Woodson, Command Forester, U.S. Army Materiel Command; Dean E. Pidgeon, Biologist, Geochemical Sciences Branch, Research Division; and David W. Cate, Technical Publications Editor, Technical Communications Branch, Information Management Division, CRREL. This survey was funded by the Natural Resources Office, U.S. Army Materiel Command, Rock Island, Illinois, under the direction of William Woodson. The manuscript was technically reviewed by Paul Miyares and Dr. Giles Marion, both of CRREL.

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Management of Vegetation on Ammunition Magazines at AMC Facilities

A.J. PALAZZO, C.H. RACINE, W. WOODSON, D.E. PIDGEON AND D.W. CATE

INTRODUCTION

Ammunition magazines, commonly called igloos, are large, above-ground, earth-covered bunkers used to store munitions at almost all military facilities (Fig. 1). Properly maintained igloos have perennial, well-knit vegetation cover that reduces erosion, have relatively low maintenance costs, provide wildlife habitat and grazing land, and are pleasing to look at. On poorly managed igloos, soil erodes at an excessive rate, and they become unsafe and need to be rebuilt. They also become covered with annual weeds, which do not retard soil erosion during the winter and are not useful for agricultural purposes. An ideal vegetation would require little or no maintenance, would retard soil erosion, would not become a fire hazard and would resist invasion by woody vegetation and annual weeds. Obviously the agronomic sciences are a long way from developing or selecting such a species; therefore, techniques are needed to develop management practices to fit these requirements.

The purpose of this project was to survey Army Materiel Command (AMC) facilities to determine their strategies for managing ammunition bunkers, or igloos. This work is part of a research program to develop cost-effective methods for safely establishing and maintaining vegetation on igloos. The results of the survey will be used to help standardize management requirements at all facilities, improve vegetation management techniques, and plan research objectives in areas where there is limited information. To our knowledge, no work has been done in developing suitable management practices or observing the methods being used to manage the vegetation on these structures.

The techniques developed must be acceptable AMC-wide and not only to Natural Resources person-

nel. Several other facility departments and divisions are involved directly or indirectly in igloo maintenance and management. These include Quality Assurance and Surveillance; Safety, Security and Fire; and Environmental and Pest Control. The responsibilities of these groups, which may differ, are listed in the AMC-R 385-100 Safety Manual.

METHODS

The survey was conducted through a six-page questionnaire (Appendix A) sent in May 1989 to the Natural Resource Specialists at all of the 36 AMC facilities that store ammunition in igloos. This includes Army Ammunition Plants (AAP), Army Ammunition Depots (AAD) and Army Testing and Evaluation Facilities (Fig. 2). The types of ammunition magazines considered here are similar to those found at most Army, Navy and Air Force bases or training areas.

The questionnaire consisted of short questions related to

- The location, climate and soils of the facility;
- The number of igloos and their aspect;
- The existing vegetation cover on igloos, in terms of species and height;
- The influences on this vegetation in terms of wildlife, fire and grazing;
- Vegetation management techniques used, including costs;
- Igloo problems such as leaking; and
- Vegetation research needs.

Of the 36 AMC facilities to whom questionnaires were sent, 34 provided satisfactory responses. These 34 areas manage 18,451 of the approximately 18,624 igloos maintained by AMC. The questionnaire was also



Figure 1. Earth-covered igloo at Lexington Bluegrass Army Depot.

presented at the annual meetings of the Agronomy Society of America (Division A-2) in 1988 and 1989.

RESULTS

Geography

The first questions in the survey concerned the locations and climate of the facilities and the number of igloos they manage (Table 1). The survey covered 18,451 igloos at 34 facilities in 28 states. There was an average of 545 igloos per facility. The range in igloo numbers per facility was from 2 at Tobyhanna Army Depot in Tobyhanna, Pennsylvania, to 2263 at McAlester Army Ammunition Plant in McAlester, Oklahoma.

The latitudes of facilities range from 33.26 to 45.50°N, and longitudes range from 75.25 to 119.17°W. In general they cover a wide geographic area and are not clustered in certain locations. About 60% (11,000) of all igloos are located west of the Mississippi River. The elevations range from 57 ft on the Gulf Coast in Louisiana to 6685 feet in the mountains of Arizona (Navajo AAP), but most facilities are below 1000 feet.

Climate

The igloos are located in four major climatic areas:

- Warm or cool-dry, with 7 facilities and 40% of the igloos;

- Dry-humid transition, with 7 facilities and 20% of the igloos;
- Warm-humid, with 5 facilities and 14% of the igloos; and
- Cool-humid, with 15 facilities and 26% of the igloos.

July temperatures at the facilities range from 63 to 85°F, with most in the mid-70s to mid-80s. January temperatures range from 14 to 47°F (Table 2). Precipitation at the facilities ranges from 5.6 to 53.2 inches per year. Most are in areas receiving greater than 30 inches per year. Only seven facilities have less than 30 in. of precipitation annually, but they manage 7454 igloos, or 40% of the total.

Igloo designs

Several types of igloos occur at each facility (Fig. 1), with varying designs and slope angles. These include mounded concrete, Stradley, steel oval arch, and steel arch igloos. The most common design is the Stradley type, which has outer dimensions of about 80–100 ft long, 80–100 ft wide and 15–20 ft high (Fig. 1). The inside cement floor area is about 26 × 60 ft. Some of the smaller steel arch igloos have a cement floor width of only 8–14 ft and an outside earth cover width of 50 ft.

A cement headwall, located at the front, contains the entrance doors. While some headwalls are truncated, others (of newer design) extend the full width (Fig. 3). The back of the igloo consists of a steep earth

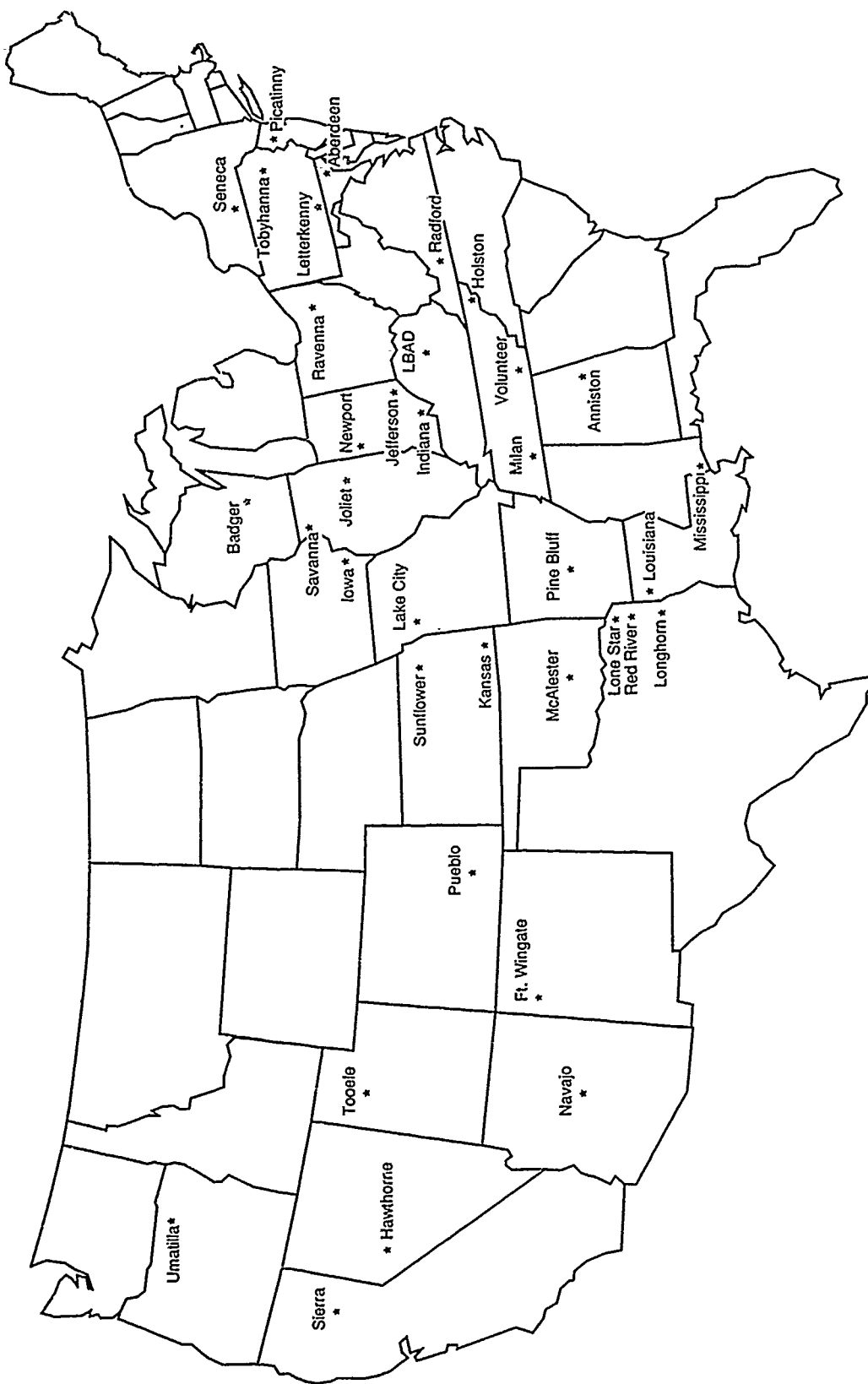


Figure 2. Locations of Army ammunition depots and plants surveyed.

Table 1. Geographical characteristics.

Name	Location	No. of igloos	Latitude (°N)	Longitude (°W)	Elevation (ft)	Orientation	
						N-S (%)	E-W (%)
Dry							
Ft. Wingate	Gallup, N.M.	731	35.32	108.45	6468	0	731
Hawthorne	Hawthorne, Nev.	2055	38.33	118.39	1200	1069	986
Navajo	Bellemont, Ariz.	725	35.14	111.50	6685	363	362
Pueblo	Pueblo, Co.	922	38.15	104.36	4600	0	922
Sierra	Herlong, Cal.	806	40.44	120.60	1500	202	604
Tooele	Tooele, Utah	1214	40.33	112.17	5070	1214	0
Umatilla	Hermiston, Ore.	1001	45.50	119.17	624	0	1001
Dry-humid transition							
Iowa	Middletown, Iowa	240	41.10	91.00	550	240	0
Kansas	Parsons, Kan.	200	37.20	95.16	910	120	80
Lake City	Independence, Mo.	11	39.06	94.26	1010	11	0
Lone Star	Texarkana, Tex.	200	33.26	94.04	390	20	180
McAlester	McAlester, Ok.	2263	34.56	95.46	760	1697	566
Red River	Texarkana, Tex.	702	33.26	94.04	390	702	0
Sunflower	DeSoto, Kan.	8	38.59	94.58	1010	8	0
Warm, humid							
Anniston	Anniston, Al.	1279	33.39	85.47	611	0	1279
Louisiana	Shreveport, La.	176	32.30	93.46	180	176	0
Milan	Milan, Tenn.	891	35.54	88.47	490	873	18
Mississippi	Stennis Space Ctr, Miss.	30	30.30	89.00	30	30	0
Pine Bluff	Pine Bluff, Ark.	278	34.13	92.01	215	139	139
Cool, humid							
Baeger	Baraboo, Wis.	25	43.29	89.44	823	22	3
Holston	Kingsport, Tenn.	141	36.33	82.33	1284	71	70
Indiana	Charlestown, Ind.	176	38.46	85.39	525	176	0
Jefferson	Madison, Ind.	34	38.45	85.25	455	3	31
Joliet	Joliet, Ill.	395	41.37	88.05	543	217	178
LBAD	Richmond, Ken.	901	37.45	84.20	980	405	496
Letterkenny	Chambersburg, Pa.	902	39.56	77.38	640	541	361
Newport	Newport, Ind.	54	39.53	87.25	555	2	52
Picatinny	Picatinny Arsenal, N.J.	36	41.00	75.10	350	34	2
Radford	Radford, Va.	214	37.06	81.33	1730	203	11
Ravenna	Ravenna, Ohio	683	41.10	81.20	1107	683	0
Savanna	Savanna, Ill.	437	42.05	90.09	700	437	0
Seneca	Romulus, N.Y.	519	42.30	76.30	500	0	519
Tobyhanna	Tobyhanna, Pa.	2	41.11	75.25	1935	2	0
Volunteer	Chattanooga, Tenn.	200	35.01	85.15	692	100	100

slope up to a vent with an indicator flag, which indicates if the vent is open or closed. Twelve of the 34 facilities (35%) use an extension on this flag to increase its visibility. Twenty one (62%) did not use an extension rod and one did not reply.

The steepness of the side and back slopes varies with igloo design. For example, igloos with complete headwalls usually have slopes that are not as steep as those with truncated headwalls. Only four facilities have igloos with slopes less than 25%; they manage 1834 igloos, or 10% of the total. Fifteen facilities, which manage about half of the igloos surveyed (9348), have slopes ranging from 25 to 50%. Fourteen facilities, which

manage 6544 igloos (33%), reported slopes of 50–75%.

The orientation of the igloos is evenly divided, with 53% of the igloos having slopes that face north-south and 47% with slopes facing east-west (Table 1). Our studies at Lexington Bluegrass Army Depot showed that orientation creates strong vegetation and microclimatic differences. Many of the facilities use some type of pattern in igloo placement, with orientation evenly divided or all igloos facing in one direction.

Soils

Facilities were surveyed concerning soil types and incidence of soil erosion (Table 3). The greatest number

Table 2. Climatic differences.

Name	No. of igloos	July high temperature (°F)	Jan. low temperature (°F)	Mean annual temperature (°F)	Mean annual precipitation (in.)	Nearest U.S. weather station
Dry						
Ft. Wingate	731	ND*	ND	51.0	10.0	Gallup FAA AP
Hawthorne	2055	ND	ND	55.0	5.6	ND
Navajo	725	63	25	42.7	25.7	Walnut Canyon
Pueblo	922	ND	ND	51.0	11.5	Pueblo
Sierra	806	ND	ND	48.6	7.6	ND
Tooele	1214	76	30	62.0	16.5	Tooele
Umatilla	1001	74	32	55.0	8.8	Hermiston
Dry-humid transition						
Iowa	240	ND	ND	51.8	36.6	ND
Kansas	200	81	33	58.3	40.3	Parsons
Lake City	11	80	33	53.7	37.0	Independence
Lone Star	200	85	47	79.0	45.0	Texarkana
McAlester	2263	83	38	63.0	42.0	McAlester FAA AP
Red River	702	85	47	79.0	45.0	Texarkana
Sunflower	8	ND	ND	54.6	36.7	Hillsdale Lake
Warm, humid						
Anniston	1279	80	43	62.1	53.2	Anniston FAA AP
Louisiana	176	83	46	65.1	46.3	Shreveport downtown
Milan	891	79	36	58.0	50.7	Milan
Mississippi	30	ND	ND	72.0	ND	ND
Pine Bluff	278	ND	ND	63.0	52.0	Pine Bluff
Cool, humid						
Badger	25	70	14	47.0	30.0	Baraboo
Holston	141	76	37	55.9	41.2	Kingsport
Indiana	176	79	34	57.0	42.0	Charlestown Ord. Plt
Jefferson	34	79	33	ND	49.0	Madison Sewage Plt
Joliet	395	76	24	50.3	35.5	Joliet Brandon
LBAD	901	76	32	54.1	36.5	Richmond
Letterkenny	902	73	29	51.6	40.6	Chambersburg
Newport	54	76	26	52.1	39.1	Terre Haute
Picatinny	36	ND	ND	ND	ND	ND
Radford	214	67	30	57.7	39.2	Radford
Ravenna	683	73	27	49.8	34.5	Ravenna
Savanna	437	72	18	50.0	34.0	Mount Carroll
Seneca	519	ND	ND	47.0	ND	ND
Tobyhanna	2	66	23	50.0	49.0	Tobyhanna
Volunteer	200	79	39	59.4	52.6	Chattanooga

* ND = no data.

of facilities and igloos have soils consisting of fine soil particles (silts and clays). Four facilities, with 3898 igloos, have only sand (mostly in arid regions), and 17 facilities listed silt or clay without sand (in humid areas). Ten facilities listed both sand and silt or clay, and one (Navajo) specified cinders as the soil texture. Three facilities provided quantitative information on the proportions of sand, silt, clay and stones in the soils covering the igloos. Only five facilities have their soil tested to determine fertility levels.

Data about the severity of soil erosion are presented in Table 3. Nearly 50% of the facilities responded that

they had minor amounts of erosion on igloo slopes. Thirteen facilities (41%) stated that they had moderate or severe erosion. Only six facilities have no erosion or a negligible amount. One facility reported having foot-deep channels on their slopes. Replacement of soil on igloo slopes was required at least once per igloo every five years at 10 facilities. Seven facilities stated that no soil replacement was required. Ten did not respond to this question, and seven reported only occasional or "as needed" repairs.

Although not asked on the questionnaire, two facilities mentioned that they had severe erosion along the



Figure 3. Igloo with a truncated headwall.

headwalls. We have also seen this problem at other facilities that we have visited. On igloos with short wingwalls, the slope along the end of the wingwalls or headwalls are usually quite steep. Erosion is usually increased in this area because runoff usually occurs along the concrete walls. Also, if grazing is allowed on the igloos, the cattle use this area to reach the top of the structure, compacting the soil and increasing erosion.

Soil depth is measured on igloos to determine if the required 2 ft of soil is present on the ridge. Of the 35 facilities surveyed, the land managers used this information at 13 of the facilities. These facilities managed 6806 igloos, or 37% of the total. Soil depth measurements are gathered by the safety office. This information would be useful to the land manager since it would provide a quantitative basis for determining how successful existing management practices are in retarding soil erosion.

Existing vegetation on igloos

The vegetation cover on igloos varies with climate (Tables 4-6). The seven facilities in Oregon, California, Nevada, Utah, Colorado, Arizona and New Mexico are all located in a dry climate region of desert and steppe. Sagebrush shrubland is the dominant natural vegetation type (Fig. 1). These facilities contain over 7454 igloos, or 40% of all the igloos surveyed. Rainfall is less than 25 inches per year, and the igloo slopes have only a sparse vegetation cover. Two facilities (Hawthorne, Nevada, and Pueblo, Colorado) responded that all of their igloos (totaling 2977) have less than 50% vegeta-

tion cover. The vegetation cover that does exist is mostly dryland or desert grasses and sagebrush shrubs. Four of these areas (Tooele, Navajo, Ft. Wingate and Pueblo) are located at higher elevations (4600-6685 ft), which results in somewhat more favorable growing conditions. Ft. Wingate in Arizona at 6468 ft lists ponderosa pine as occasionally growing on igloos. Vegetation height on igloos in this arid region ranges from 2 to 36 inches, and the facilities do not try to keep the vegetation below a certain height. Four of these seven facilities have extension flags on the vents, although there is probably little vegetation to obstruct their visibility.

A second group of seven facilities are located in the midwest in a transition region between warm-dry and warm-humid climates, where tall grass prairie and oak-hickory are the successional species (Iowa, Missouri, Oklahoma, eastern Texas, Kansas). These represent 3624 igloos, or 20% of the total. Several native prairie grasses grow on these igloos, including bluestem and switchgrass, while brome and bluegrass have been planted extensively. In the more southern areas of McAlester, Oklahoma, and Texarkana, Texas, bermudagrass is common, along with the native prairie grasses. Woody vegetation does not appear to be a problem on these igloos. Ragweed and thistle are common, along with some vines such as trumpet creeper and bindweed. Three facilities in this group manage vegetation below a certain height.

There are five facilities (western Tennessee, Arkansas, Alabama, Mississippi and Louisiana) that are

located in warm-humid areas. There are 2654 igloos at these facilities, or 14% of the total number of igloos. Bermudagrass is the major grass in these areas. Three of these facilities manage vegetation to keep it below a certain height.

Finally, a fourth group of igloos are located in the cool-humid climate stretching from the north to the northeast and down the Appalachians to Tennessee. This group of seven facilities in Ohio, Indiana, Wisconsin, New York, Pennsylvania and New Jersey include

3245 igloos, or 17% of the total. Vegetation on these igloos is mainly cool-season grasses such as timothy, bluegrasses, bromegrass and fescues. Six other facilities in Illinois, Indiana, eastern Kentucky, eastern Tennessee and western Virginia are in a somewhat warmer or transitional area from cool-humid to warm-humid climates. The facilities in Tennessee, Virginia and Kentucky are located in or near the Appalachian Mountains and are therefore cooler than facilities farther south or at lower elevations. Five of these facilities manage their

Table 3. Soil characteristics.

Name	No. of igloos	Sand	Silt	Clay	Stony	Erosion	Repairs in 5 yrs?	Dep'th measured?	Soil test results?
Dry									
Ft. Wingate	731	0*	0	X	0	Some wind	Yes	No	ND
Hawthorne	2055	X	0	0	0	Moderate	No	ND	ND
Navajo	725	Cinders	—	—	X	Slight	No	No	No
Pueblo	922	X	X	0	0	Major	Yes	Yes	Yes
Sierra	806	X	0	0	0	Severe	Yes	Yes	No
Tooele	1214	X	X	X	X	Moderate	No	No	No
Umatilla	1001	X	0	0	X	Slight	Yes	Yes	No
Dry-humid transition									
Iowa	240	0	X	X	0	Average	As needed	Yes	No
Kansas	200	0	X	X	0	Slight	No	No	No
Lake City	11	35%	15%	50%	0	Slight	ND	No	No
Leone Star	200	X	X	X	0	Slight	Once	Yes	Yes
McAlester	2263	X	0	X	0	Moderate	Once	Yes	Yes
Red River	702	0	22%	65%	3%	Some (2-3%)	Once	ND	No
Sunflower	8	X	0	X	0	ND	Once	ND	No
Warm, humid									
Anniston	1279	0	0	X	X	Moderate	Occasional	No	No
Louisiana	176	X	X	X	0	Slight	Seldom	Yes	No
Milan	891	0	X	0	0	Negligible	ND	No	No
Mississippi	30	X	0	X	0	Moderate	None	Yes	No
Pine Bluff	278	0	X	0	0	Moderate	As needed	No	Yes
Cool, humid									
Badger	25	ND	ND	ND	ND	None	ND	No	No
Holston	141	0	0	X	0	Minor	Yes	Yes	Yes
Indiana	176	0	0	X	0	Slight	Occasional	Yes	No
Jefferson	34	0	X	X	0	None	ND	No	No
Joliet	395	0	X	X	0	Moderate	Occasional	No	No
LBAD	901	0	0	X	0	M. severe	None	No	No
Letterkenny	902	ND	ND	ND	ND	Minimal	None	No	No
Newport	54	0	X	0	0	Minimal	ND	No	No
Picatunny	36	X	0	0	X	Not severe	ND	No	No
Radford	214	20%	0	80%	0	Slight	ND	Yes	No
Ravenna	683	0	0	X	0	Minor	ND	No	No
Savanna	437	X	X	X	0	Moderate	Yes	Yes	No
Seneca	519	0	X	X	0	Negligible	ND	No	No
Tobyhanna	2	0	0	X	X	None	ND	No	No
Volunteer	200	0	X	X	0	Minor	As needed	Yes	No

*X = present

0 = not present

ND = no data

vegetation to keep it below a certain height.

Although igloos were originally seeded with grasses and legumes at the time of construction or restoration, shrubs, trees, vines and herbaceous weeds have invaded. Legumes such as lespedeza are listed for the southern facilities (Kentucky, Tennessee, Alabama and Kansas). Clover is more common in the north. Only Tobyhanna listed crownvetch as growing on igloos.

The seven facilities in the arid west list shrubs (particularly sagebrush) as common and comprising up

to 50% cover. Trees are not a problem here, except for ponderosa pine at Navajo Army Ammunition Depot at 6685 ft in the mountains of Arizona.

Vegetation uses and influences

The purpose of this set of questions was to identify the various values of the vegetation on igloos in terms of wildlife habitat and to determine other factors in the environment that might affect the vegetation including grazing and fire (Table 7).

Table 4. Types of existing vegetation on igloos.

Name	No. of igloos	Vegetation (% cover)					
		Grasses	Legumes	Weeds	Trees	Shrubs	Vines
Dry							
Ft. Wingate	731	X*	0	ND	0	X	0
Hawthorne	2055	0	0	0	0	2	0
Navajo	725	75	0	0	5	20	0
Pueblo	922	40	0	ND	ND	ND	0
Sierra	806	40	0	10	0	50	0
Tooele	1214	X	0	0	0	X	0
Umatilla	1001	X	0	X	0	0	0
Dry-humid transition							
Iowa	240	ND	ND	0	0	0	0
Kansas	200	80	0	10	1	10	0
Lake City	11	ND	1	X	0	0	1
Lone Star	200	90	4	2	0	0	4
McAlester	2263	60	5	10	0	20	5
Red River	702	ND	0	ND	0	ND	0
Sunflower	8	X	0	ND	0	0	0
Warm, humid							
Anniston	1279	70	10	3	5	5	2
Louisiana	176	60	5	20	3	2	10
Milan	891	90	ND	X	3	3	4
Mississippi	30	90	0	10	0	0	0
Pine Bluff	278	85	2	3	4	6	0
Cool, humid							
Badger	25	60	0	40	0	0	0
Holston	141	90	10	0	0	0	0
Indiana	176	80	ND	0	0	20	0
Jefferson	34	ND	0	X	0	0	0
Joliet	395	ND	0	X	0	ND	0
LBAD	901	ND	ND	X	ND	ND	2
Letterkenny	902	95	ND	0	1	1	ND
Newport	154	100	0	0	0	0	0
Picatinny	36	ND	ND	X	0	0	ND
Radford	1214	100	0	0	0	0	0
Ravenna	683	90	0	7	1	8	1
Savanna	437	ND	ND	0	5	ND	4
Seneca	519	ND	ND	ND	ND	ND	ND
Tobyhanna	2	ND	X	X	ND	ND	ND
Volunteer	200	ND	ND	ND	X	ND	ND

*X = present

0 = not present

ND = no data

Table 5. Species of vegetation observed on igloos for each climatic region.

<i>Climatic region</i>	<i>Vegetation</i>
Dry	Grasses, desert grass, buffalo grasses, dryland grass, sage, rabbitbush, ponderosa pine
Dry-humid transition	Brome, grasses, Kentucky bluegrass, fescue, meadow fescue, bermudagrass, dallisgrass, johnsongrass, bahiagrass, bluestem, vaseygrass, clover, lespedeza, pigweed, thistle, musk thistle, thistle, bindweed, trumpet creeper, thistle, rose, beauty berry, privet, blackberry, mulberry, honeysuckle, sumac, red cedar
Warm, humid	Bermudagrass, fescue, johnsongrass, native grass, broomsedge, lespedeza, clover, fern, daffodils, pokeberry, Virginia creeper, trumpet creeper, grape, sumac, blackberry, honeysuckle, briar, sweetgum, pine, red cedar
Cool, humid	Grasses, fescue, broomsedge, bluegrass, Kentucky bluegrass, little bluestem, foxtail, squirreltail, ryegrass, tall fescue, redtop, timothy, Canada bluegrass, chewings fescue, brome, crownvetch, clover, lespedeza, mullein, mustard, aster, thistles, ferns, trumpet creeper, Virginia creeper, poison ivy, ivy, grape, hawthorn, multiflora rose, hornberry, briars, blackberry, honeysuckle, switch, aromatic sumac, cedar, locust, redbud, oak, elm, maple, ash

Table 6. Vegetation management goals.

<i>Name</i>	<i>No. of igloos</i>	<i>Management goals</i>	<i>Vegetation height (in.)</i>	<i>Recommended height (in.)</i>	<i>No. of igloos with <50% cover</i>
Dry					
Ft. Wingate	731	None	24-36	ND	35
Hawthorne	2055	None	NA	ND	100
Navajo	725	None	18	5	3
Pueblo	922	None	12-24	None	100
Sierra	806	None	36	36	1
Tooele	1214	None	6-12	8	0
Umatilla	1001	None	2-14	None	None
Dry-humid transition					
Iowa	240	None	2-16	3-6	0
Kansas	200	None	6-12	6-12	0
Lake City	11	Yes	8	None	0
Lone Star	200	None	10	10	0
McAlester	2263	18	18	18	0
Red River	702	24	48-72	24	0
Sunflower	8	ND	ND	3-4	ND
Warm, humid					
Anniston	1279	<8	8-48	8	4
Louisiana	176	5-10	5-24	5-7	2
Milan	891	None	4-6	4-6	0
Mississippi	30	None	8	8	0
Pine Bluff	278	≤8	18-24	8-12	25
Cool, humid					
Badger	25	None	4-6	None	0
Holston	141	None	6-8	6-8	0
Indiana	176	4	4-8	6	0
Jefferson	34	None	18-24	None	0
Joliet	395	None	24 in	None	0
LBAD	901	ND	6-30	<8	0
Letterkenney	902	None	24	NA	0
Newport	154	Rem.woody	<36	None	0
Picatinny	36	ND	24-30	12-18	0
Radford	1214	3-4	4-6	3-4	0
Ravenna	683	Unob.vent	4-24	4	0
Savanna	437	<12	4-8	<12	15
Seneca	519	8-12	24-30	ND	0
Tobyhanna	2	12	12	12	0
Volunteer	200	None	12-24	ND	0

Wildlife

All except two facilities stated that wildlife use igloos. Fourteen facilities mentioned that deer and birds such as quail and turkey use the igloos. In areas subject to occasional flooding, igloos would provide "high and dry" nesting habitats. In areas of flat terrain, igloos would provide observation platforms for predators such as owls, foxes and coyotes. Antelope were mentioned as users of igloos in New Mexico and Colorado, and coyotes were mentioned by six facilities. We have observed geese landing on igloos in Kentucky.

Burrowing animals such as groundhogs and badgers make holes on igloo slopes (Fig. 4). These can cause bare soil exposure and channels for water movement to the igloo structure, as well as sites for the establishment of annual or biennial weeds such as thistle. Twelve facilities (35%) said that burrowing animals were not a problem on their igloos. Ten facilities (29%) said burrowing animals were a problem, while 12 answered that burrowing animals were an occasional or moderate problem. Control of burrowing animals included fumigation with phostoxin or poison

Table 7. Animal influences on vegetation.

Name	No. of igloos	Wildlife	Burrowing animals	Animal control	Igloos grazed	
					(%)	(no.)
Dry						
Ft. Wingate	731	Antelopes, buffalo	Some	Shot	0	0
Hawthorne	2055	None	Yes	Poison	0	0
Navajo	725	Elk, deer	Yes	Shot	100	725
Pueblo	922	Antelopes, rabbits, badgers	Some	None	0	0
Sierra	806	Badgers, owls	Occ.	Dirt in holes	0	0
Tooele	1214	Deer, rabbits	Some	No reply	100	1214
Umatilla	1001	Coyotes, rabbits	Occasional	Infreq trap	0	0
Dry-humid transition						
Iowa	240	Badgers, groundhogs, coyotes	Yes	Trapping	40	96
Kansas	200	Badgers, coyotes, skunks, rodents	Sl-Mod	Fill burrow	100	200
Lake City	11	Quail, rodents, snakes, deer	Moderate	None	0	0
Lone Star	200	Deer, rabbits	Occasional	Trap gophers	0	0
McAlester	2263	Turkeys, deer, coyotes, bobcats, quail	None	None	0	0
Red River	702	Deer, quail, songbirds	Yes	Trapped	0	0
Sunflower	8	ND	No	None	0	0
Warm, humid						
Anniston	1279	Deer, turkeys, doves	None	None	78	998
Louisiana	176	Deer, squirrels, rabbits	Occasional	None	0	0
Milan	891	Groundhogs, foxes, coyotes, rabbits, birds	Minor	Trap	100	891
Mississippi	30	Armadillo	None	None	0	0
Pine Bluff	278	Deer, nongame birds	None	None	0	0
Cool, humid						
Badger	25	Deer	None	None	88	22
Holston	141	Deer, turkeys	Yes	Fill holes	0	0
Indiana	176	Deer, rabbits, quail, groundhogs	Yes	Trap, shoot, poison	100	176
Jefferson	34	Hawks, deer, mice	None	None	0	0
Joliet	395	Coyotes	None	None	50	198
LBAD	901	Deer, geese, foxes, raccoons, groundhogs	Yes	None	75	676
Letterkenney	902	Whitetail deer	Minor	Fumigate*	0	0
Newport	54	None	None	None	0	0
Picatinny	36	Deer, turkeys, woodchucks, snakes	None	None	0	0
Radford	214	Deer, groundhogs, rabbits	Yes	Fumigate*	0	0
Ravenna	683	Deer, groundhogs, roosting birds	Yes	Fumigate*	0	0
Savanna	437	Deer, raccoons, woodchucks, foxes	Occasional	Fill hole	100	437
Seneca	519	Woodchucks, mice	Yes	Trapped	0	0
Tobyhanna	2	Birds, rodents	None	None	0	0
Volunteer	200	None	None	None	0	0

*Phostoxin.

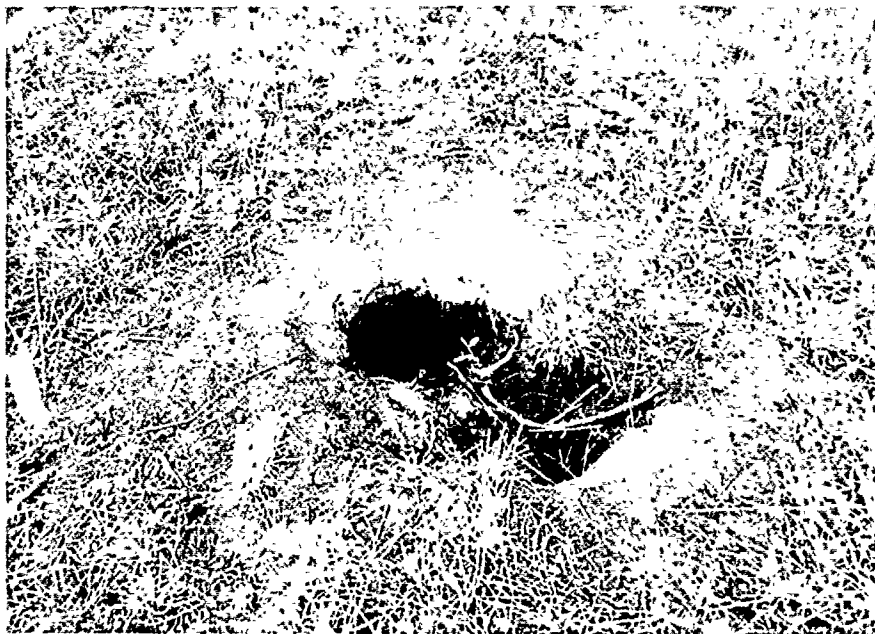


Figure 4. Hole of a burrowing animal on an igloo surface.

by five facilities, shooting (three facilities), trapping (seven) and filling the burrow with soil (four). Sixteen facilities said that they did not practice any control of burrowing animals, even though at least three of these facilities answered that they had a problem with burrowing animals.

Grazing

Grazing leases are negotiated on 11 facilities, where from 40 to 100% of the igloos are actually grazed (Fig. 5). The total number of igloos grazed is 5633, or 30% of the total. About half of these (2565 igloos) are located in Tennessee, Kentucky and Alabama. About 2000



Figure 5. Cattle grazing on an igloo at Lexington Bluegrass Army Depot in Kentucky. Grazing leases exist at 11 facilities, representing about 30% of all igloos surveyed.

igloos are grazed in Utah and Arizona, while the remaining 1100 grazed igloos are located in Illinois, Kansas, Iowa, Indiana and Wisconsin.

Our vegetation research at Lexington Bluegrass Army Depot, where 75% of the 901 igloos are grazed, suggests that grazing has a strong impact on igloo soils and vegetation. The impacts include soil compaction and erosion and the spread of annual weed seeds.

Wildfire

We asked how often wildfires occur in the geographical region of each facility. At least six facilities answered that wildfires occurred at a frequency of one or more per year (Table 8). Umatilla (Hermiston, Or-

egon) and McAlester, Oklahoma, listed fire frequencies as six fires per year. The time of regional wildfires was during the fall or spring at most of the eastern U.S. facilities and during the summer in the west. Twenty-five facilities responded that they did not manage vegetation for the threat of wildfires, while nine facilities said that they did manage vegetation for this purpose.

Vegetation management

Mowing

Over half of the facilities (21) containing 71% of the igloos (13,020) reported that they do not mow the vegetation on the igloos slopes (Table 9, Fig. 6). Of the 11 facilities where grazing occurs, 10 do not mow.

Table 8. Influence of fire on vegetation.

Name	No. of igloos	Wildfire frequency	Wildfires reg. time
Dry			
Ft. Wingate	731	2-3/year	ND
Hawthorne	2055	Low	Aug-Nov
Navajo	725	High	May-Oct
Pueblo	922	Low	ND
Sierra	806	2-3/year	Summer
Tooele	1214	Low	Late summer
Umatilla	1001	6/year	July, Aug, Sept
Dry-humid transition			
Iowa	240	Low	ND
Kansas	200	Annually	Mar-June
Lake City	11	1/10 years	Winter
Lone Star	200	Low	Summer
McAlester	2263	5-6/year	Feb, July, Aug
Red River	702	Low	ND
Sunflower	8	Low	ND
Warm, humid			
Anniston	1279	Mod	Spring/Fall
Louisiana	176	High	Oct-Apr
Milan	891	Low	Dec-March
Mississippi	30	High	Summer/Fall
Pine Bluff	278	High	Spring/Fall
Cool, humid			
Badger	25	Low	Late summer
Holston	141	4/year	Summer/Fall
Indiana	176	Low	Spring
Jefferson	34	Low	Spring/Fall
Joliet	395	Low	ND
LBAD	901	Low	July-Aug
Letterkenny	902	Low	ND
Newport	54	Low	Summer
Picatinny	36	Low	ND
Radford	214	Low	ND
Ravenna	683	Low	Spring/Fall
Savanna	437	Low	ND
Seneca	519	Low	ND
Tobyhanna	2	High	Spring/Fall
Volunteer	200	Low	Aug-Sept

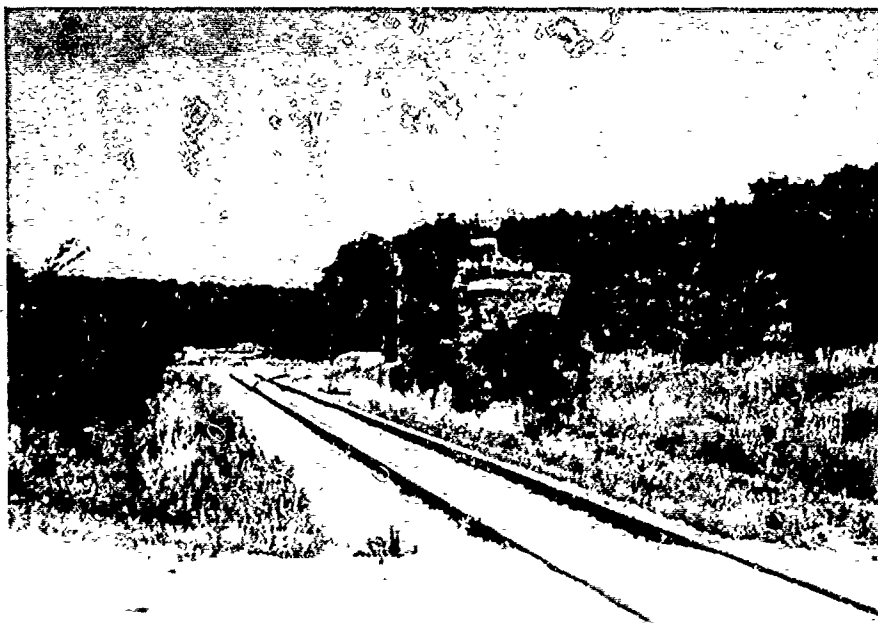


Figure 6. Mowing of igloo vegetation at McAlester AAP, McAlester, Oklahoma, using hydraulic mowers pulled by small bulldozers.

Fertilizer use

Only six facilities (representing 3088 igloos), or 17% of the total, fertilize the igloo vegetation. McAlester, with 2263 igloos, represents most of this total. All of these facilities also mow, except for Lone Star in Texas, with 200 igloos.

Herbicide use

About half of the facilities use herbicides to control vegetation on igloos. This represents 7669 igloos, or about 42% of the total. Savanna Army Depot in Illinois uses occasional spot treatments to prevent tree regrowth. None of the facilities in the western states (Oregon, California, Nevada, Utah, Arizona, New Mexico and Colorado) use herbicides. At least one of the facilities that does not use herbicides does hand clearing with brushsaws (Mississippi).

The remaining 17 facilities use one to several types of herbicides to control broadleaf weeds and woody vegetation. Thistle (particularly musk thistle), multiflora rose, briars, red cedar, johnsongrass, sumac and honeysuckle are targets in the east. Eight of these use 2,4-D. Other herbicides include MSMA (three facilities), Banvel (four), Oust (two), Tordon (three) and Garlon (two).

In 1988 the Lake City AAP in Independence, Missouri, conducted a study to determine how mowing and herbicide treatments affected the vegetation cover and maintenance costs. The best vegetation stand resulted from mowing three times per season and one

herbicide (2,4-D) treatment at a cost of \$586 per igloo.

Overseeding

Only five facilities responded that they overseeded igloo vegetation to improve the vegetation cover. Another two facilities said that they did this occasionally.

Costs

The combined annual costs to maintain vegetation on an igloo varied widely and were grouped in the following categories: \$0-1 (six facilities), \$30-60 (six facilities), \$100-300 (five facilities), \$400-500 (two facilities) and \$1200 (one facility with 30 igloos) (Table 10). The remaining 14 facilities did not respond to this question or said "minimal."

Igloo renovation

Igloo renovation involves removing the earth cover, repairing the superstructure and replacing the soil cover (Fig. 7). Then the surface must be reseeded and mulched to establish a new vegetation cover (Fig. 8). This is clearly expensive, costing up to \$35,000 per igloo. Six facilities responded that they renovated 5-30 igloos per year (Table 5).

Igloo coverings

We asked if there was an initiative to cover igloos with plastic or other materials (Table 9). McAlester, Kansas, Mississippi and Sunflower said that plastic

Eleven of the 21 facilities that do not mow are located in drier areas west of the Mississippi River and represent 63% of the igloos that are not mown.

At Pueblo a 50-ft-wide security strip is mowed around each igloo, but the igloo slopes are not mowed. At Letterkenny in Chambersburg, Pennsylvania, mowing is carried out only around the vent of each igloo by an all-terrain vehicle.

The remaining 13 facilities, representing 5431 igloos (29%), mow igloo vegetation from one to three times per summer. With the exception of McAlester, these facilities generally have fewer igloos than the bases that do not mow. McAlester in Oklahoma has almost half of the mowed igloos (2263) and has developed specialized hydraulic bush hogs and tracked vehicles to mow the steep igloo slopes.

Table 9. Vegetation management practices.

<i>Name</i>	<i>No. of igloos</i>	<i>Herbicides used</i>	<i>Frequency of mowing</i>	<i>Fertilized?</i>	<i>Over-seeding?</i>	<i>Resurface/renovate</i>	<i>Problems or covers</i>
Dry							
Ft. Wingate	731	None	0	No	No	Gravel	No
Hawthorne	2055	None	0	No	No	No	No
Navajo	725	None	0	No	No	30/year	Leaking
Pueblo	922	None	0	No	No	Gravel	No
Sierra	806	None	0	No	No	20/year	No
Tooele	1214	None	0	No	No	No	Leaking
Umatilla	1001	None	0	No	Occas.	No	Some Cracks
Dry-humid transition							
Iowa	240	Amine: 2,4-D	0	No	No	Yes	Condensation
Kansas	200	None	0	No	No	No	Plastic
Lake City	11	2,4-D	3	No	No	No	No
Lone Star	200	MSMA	0	Yes	Yes	Yes	Leaking
McAlester	2263	None	1	Yes	Yes	Yes	Plastic
Red River	702	MSMA, Banvel	0	No	No	No	Leaking
Sunflower	8	None	0	No	No	No	Plastic
Warm, humid							
Anniston	1279	Weedone, Oust, Banvel, Tord etc.	0	No	No	12/year	Leaking
Louisiana	176	Oust, MSMA, 2,4-D	2	Yes	Yes	Yes	Leaking
Milan	891	Banvel 720	0	No	No	Yes	Leaking
Mississippi	30	None	1	Yes	Yes	No	Plastic
Pine Bluff	278	Roundup, Krenite	1	Yes	No	5/year	Leaking
Cool, humid							
Badger	25	Banvel, 2,4-D	0	No	No	No	No
Holston	141	2,4-D	2	Yes	Yes	Yes	Leaking/Vents
Indiana	176	None	1	No	No	Yes	Leaking
Jefferson	34	2,4-D	0	No	No	5/year	Minor Leak
Joliet	395	None	0	No	No	No	No
LBAD	901	2,4-D	0	No	No	7/year	Leaking
Letterkenny	902	Krenite, Arsenal, Embark	2	No	No	No	No
Newport	54	None	0	No	No	No	Cracking
Picatinny	36	2,4-D, trichlopyr-Crossbow	1-2	No	No	No	Feasible
Radford	214	Garlon, Escort/Embark	1-2	No	No	No	Leaking
Ravenna	683	Garlon, Weedstroy, Tordon	1	No	No	Yes	Cracking
Savanna	437	None (Hyvar XL)	0	No	Occas.	No	Some Cracks
Seneca	519	Tordon 10K (Picloram)	4	No	No	No	Leaking
Tobyhanna	2	None	1-2	No	No	No	Leaking
Volunteer	200	None	0	No	No	No	Leaking

covers are being tried or considered (Fig. 8). In November 1988 we visited McAlester to observe and discuss an effort to cover igloos with plastic. Land managers generally expressed the opinion that they do not want igloos covered in plastic. They prefer a vegetation cover, which benefits wildlife, has lower management costs and is more aesthetically appealing.

At Ft. Wingate and Pueblo there is a program to cover igloos with rock gravel to reduce wind erosion. At Pueblo a 3-inch cover of gravel less than 1.5 inches in diameter has been placed on about 400 of their 922 igloos. At Ft. Wingate the technique has worked well and encouraged the establishment of native vegetation.

NEEDS AND RECOMMENDATIONS

Research needs expressed by the land managers include:

- Using plant growth regulators and herbicides,
- Assessing the degree of problem presented by shrubs and small trees;
- Selecting vegetation that is beneficial to wildlife and requires little maintenance; and
- Encouraging native desert species in the arid west and removing and controlling sagebrush-like vegetation.

At least one facility noted that there is a need for a tight-

Table 10. Igloo management costs.

Name	No. of igloos	Vegetation management cost per igloo (\$)	Resurfacing cost per igloo (\$)
Dry			
Ft. Wingate	731	ND	ND
Hawthorne	2055	ND	ND
Navajo	725	1	5,000
Pueblo	922	ND	2,000
Sierra	806	0	900
Tooele	1214	0	ND
Umatilla	1001	500	ND
Dry-humid transition			
Iowa	240	ND	800
Kansas	200	ND	0
Lake City	11	125	0
Lone Star	200	60	150
McAlester	2263	ND	ND
Red River	792	35	ND
Sunflower	8	0	0
Warm, humid			
Anniston	1279	45	1,500
Louisiana	176	450	ND
Milan	891	ND	ND
Mississippi	30	1200	0
Pine Bluff	278	200	500
Cool, humid			
Badger	25	0	ND
Holston	141	300	2,469
Indiana	176	50	3,000
Jefferson	34	ND	35,000
Joliet	395	0	0
LBAD	901	Minimal	10,000
Letterkenny	902	ND	0
Newport	54	Minimal	0
Picatinny	36	ND	0
Radford	214	37	0
Ravenna	683	32	ND
Savanna	437	ND	0
Seneca	519	ND	0
Tobyhanna	2	240	0
Volunteer	200	200	0



Figure 7. Recently renovated igloo at Lexington-Bluegrass Army Depot in Richmond, Kentucky. The earth cover has been removed, the cement superstructure repaired and the soil replaced prior to seeding.



Figure 8. Erosion on a recently renovated igloo.



Figure 9. A "leaking" igloo at McAlester, Oklahoma, which is being covered with a plastic liner. Natural resource managers generally do not favor such coverings since igloos provide wildlife habitat and other values.

rooted, all-season native grass that grows well on poor soils and is not palatable to livestock. At least two facilities commented on the value of a database for tracking the various vegetation management practices and their success.

Several facilities mentioned that since several divisions were involved in igloo management, it was difficult to develop a vegetation cover that satisfied all groups. Five facilities said that there was duplication in the effort between the various groups that manage igloos. Nineteen said that there was no duplication, and five did not respond.

SUMMARY

Soils

Igloo soils vary in texture from sands at two western facilities to fine silts and clays at 17 facilities. Sixty-two percent of the facilities have no (or only minor amounts of) soil erosion on igloo slopes. The remaining facilities have moderate to severe erosion. At least two facilities mentioned that the problem is greatest on igloos with short headwalls. Few facilities measure the texture or fertility status of the soils on their igloos. This information would be helpful in selecting plant species and determining land management needs, such as fertilizer and lime requirements.

Vegetation

Igloo vegetation cover varies with geographic region from less than 50% cover (in Nevada and Colorado), where desert conditions exist, to 100% in the humid east and south. Three grass vegetation types can be recognized in relation to climatic location. Bermuda grass is used in the warm-humid regions (Arkansas, Mississippi, Alabama and Texas). Cool-season grasses such as fescues, ryegrass and bluegrass are used in the cool-humid areas, and prairie warm-season grasses are used in some of the transition areas of Illinois, Kansas and Oklahoma. A fourth group comprises desert areas with sparse vegetation and the potential to revegetate with desert grasses such as grama grasses, indian ricegrass, wheatgrass and other warm-season bunchgrasses. Woody vegetation, which is common on igloos in all areas, includes sagebrush in the west and blackberry, sumac, honeysuckle and rose in the east. Thistle and ragweed are major weeds on igloos in more humid regions.

Vegetation uses and influences

Wildlife use of igloos was recognized as important by almost all of the respondents. Burrowing animals were a problem at 29% of the facilities, and control included poison, trapping, shooting and filling in the burrow. Livestock grazing of igloos occurs on 11 facilities (where about 30% of all igloos are grazed), with proportions distributed equally in the east, west and

midwest. Wildfire appears to be an important regional factor at about 10 facilities, and in those areas vegetation is managed to prevent fire.

Vegetation management

Over half of the facilities, containing 71% of the igloos, reported that they do not mow igloo slopes. McAlester mows vegetation on 2263 igloos. Only six facilities (17%) apply fertilizer to igloo vegetation. Half of the facilities (representing about 42% of the igloos) apply herbicides, with 2,4-D used most commonly to

control broadleaf weeds. Lake City Army Ammunition Plant is conducting a study to compare mowing and herbicide treatments. Annual igloo vegetation maintenance can cost up to \$1200 per igloo, with most in the range of \$0-300 per igloo.

Renovation and coverings

Four facilities said that there was an initiative to cover leaking igloos with plastic. At two western facilities, igloos are being covered with rock gravel to reduce wind erosion and encourage vegetation growth.

APPENDIX A: SURVEY QUESTIONNAIRE

AMC SURVEY QUESTIONNAIRE

DEVELOPMENT OF A SAFE AND COST-EFFECTIVE VEGETATION COVER

FOR IGLOOS

Intended for completion by the installation organization responsible for performing igloo vegetation maintenance

YOU MAY NOT HAVE ALL THE ANSWERS- DO YOUR BEST!

MARCH 1989

* NAME AND LOCATION OF FACILITY: _____

* PERSON REPORTING AND TITLE: _____

* PHONE NO. _____

* POC FOR IGLOO VEGETATION MAINTENANCE: _____

Installation organization which does igloo vegetation
surveillance? _____ Is there
duplication? _____

1. HOW MANY IGLOOS DO YOU MANAGE? _____

a. Are there several different types of igloos on your base?

2. WHAT ARE THE GENERAL DIMENSIONS AND ORIENTATION?

a. What percent of the igloos are oriented i.e. side slopes facing toward: North/South _____ East/West _____

b. Slope steepness _____ %

c. Approx. Outside Height _____ ft

d. Outside Length _____ ft

e. Outside Width _____ ft

f. Inside cement floor Area (ft^2) _____

g. Do you use extension rods for ventilator indicator flags?

3. WHAT IS THE GENERAL CLIMATE IN YOUR AREA? (THIS INFORMATION IS IN YOUR NATURAL RESOURCE MANAGEMENT PLAN)

a. Climatic regime:

cool, humid
cool, dry
warm, humid
warm, dry

b. Mean annual temperature _____

c. Mean annual precipitation _____

4. WHAT ARE THE DOMINANT VEGETATION TYPES AND PERCENTAGE OF EACH ON IGLOOS (PLEASE NAME SPECIES IF KNOWN)

a. Grasses_____

b. Shrubs_____

c. Trees:

Deciduous_____

Evergreen (Conifer)_____

d. Broadleaf herbaceous (weeds)_____

e. Vines_____

f. Legumes_____

5. WHAT PERCENT OF IGLOOS ON YOUR FACILITY HAVE LOW VEGETATION COVER (LESS THAN 50% VEGETATION COVER) AND HIGH EXPOSURE OF BARE SOIL ?

6. STATURE OF THE EXISTING VEGETATION?

a. What is general vegetation height?

b. What is the recommended height?

c. Are there any height management goals?

7. IGLOO VEGETATION USES AND INFLUENCES

a. What percent of the igloos are grazed by cattle or sheep through agricultural leases?

b. What species of wildlife use the igloos?

c. How often do wildfires occur in your geographical region and what time of year do they occur?

- d. How often do wildfires occur in your ammunition storage area?
- e. Does igloo vegetation need to be managed for this threat of wildfire?
- f. Are burrowing animals a problem on igloos and how are they controlled?

8. SOILS ON IGLOOS

- a. What general types of soils occur on the igloos?

Sand_____

Silt_____

Clay_____

Stony_____

- b. Is the soil on igloos generally better or worse than the original, adjacent soils?
- c. How severe is soil erosion on igloos?
- d. If answer to b. entails significant erosion, how often is heavy equipment used to repair it? (i.e. push up soil and resurface igloos? (i.e. once every five years, etc.)
- e. Are igloo soil depth measurements available or useful for vegetation management?
- f. Are soil test results available for igloo soils?

9. MAINTENANCE PRACTICES FOR EXISTING IGLOO VEGETATION

- a. What is the estimated vegetation management costs per igloo?
- b. Do you mow the igloo vegetation cover? Yes____No____
- c. If answer to b is yes, how often do you mow?_____
- d. What type of mowing equipment do you use?
- e. Do you fertilize igloo vegetation? Yes____ No____
- f. What type, amount and how often applied?
- g. How often and how much lime is applied to igloo soils?
- h. Is there an initiative on your installation to cover igloos with plastic, etc? Yes____ No____?
- i. If answer to h. is yes, what is the status of the current program and what is your opinion of this effort?

10. DO YOU PRACTICE WEED CONTROL ON IGLOOS?

- a. What types of weeds or other plants are a problem on igloos?
- b. What type(s) of herbicide(s) are used?
- c. What are the herbicide application rates and frequencies needed for control?

11. DO YOU PRACTICE OVERSEEDING TO INCREASE VEGETATION COVER ON IGLOOS?

a. If yes, what seed mixes and rates are used?

12. HAVE YOU RECENTLY RENOVATED AND RESEDED ANY IGLOO SURFACES?

a. How many igloos are resurfaced per year?

b. What are the rates of fertilizer and lime applied?

c. What is the composition of the seed mixes used?

d. What types of mulches are used if any?

e. What is the estimated cost per igloo for resurfacing?

13. DO YOU HAVE ANY OTHER PROBLEMS WITH IGLOOS? I.E. LEAKING ETC.

14. WHAT TYPE OF VEGETATION MANAGEMENT RESEARCH WOULD YOU LIKE TO SEE PERFORMED FOR IGLOOS?

15. DO YOU THINK IT IS WORTHWHILE TO DEVELOP A SIMPLE COMPUTER SOFTWARE PROGRAM TO HELP SIMPLIFY THE DEVELOPMENT OF REVEGETATION SPECIFICATIONS FOR IGLOOS?

REPORT DOCUMENTATION PAGE

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